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Technical Notes

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A Competition Index Methodology for Northwestern Ontario

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INTRODUCTION

The reduction of competing vegetation in regenerating conifer plantations is an important silvicultural and wildlife management issue. Competition from non-crop vegetation for available light, soil water, nutrients and physical growing space can severely limit the survival and growth of young conifers (Figure 1) (Walstad and Kuch 1987). The non-crop species, however, may also serve as important sources of habitat, browse or forage for wildlife species. The selection of management option(s) to manipulate early successional vegetation should be based on an understanding of the competitive effects of the various non-crop species (Bell 1991), and an understanding of the threshold levels at which the impact becomes adverse (Buse and Baker 1991).

A major limitation to evaluating the need, timing and intensity of vegetation management treatments in northwestern Ontario is the lack of an easily-applied competition assessment procedure. To develop effective prescriptions, resource managers require information on the assemblage of non-crop species as well as their respective abundance, dominance and size. The ability to assess the impact of a treatment on both the crop and non-crop (target) species would also be highly desirable. Finally, any competition index procedure should have the potential for linking changes in conifer crop tree size, growth and vigour to the presence and abundance of the non-crop vegetation.

The purpose of this technical note is to describe a procedure for competition assessment which can be used in northwestern Ontario.

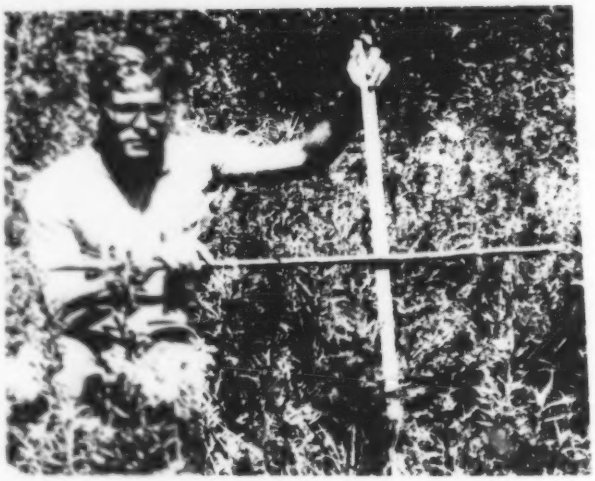

Figure 1. Non-crop species commonly compete with conifer species for rooting space, soil moisture, nutrients and sunlight. How can you describe and quantify these situations?

BACKGROUND

Although Ontario's forest managers have been actively tending and releasing conifer plantations for over 40 years, the methods used to describe and measure early successional vegetation have changed little. The recognition of a competition problem and the need for treatment is often based on a visual assessment of crop tree height and diameter growth or the relative development / dominance of either the crop or 'weed' species.

Currently, provincial surveys such as 1st-year and 2nd-year survival assessments, 5th-year stocking assessments and Free-to-Grow Surveys are used in conjunction with the Ontario Silvicultural Information System (SIS) to describe the management regime and silvicultural effectiveness of the prescription. Each of these surveys uses a competition assessment procedure where competition is coded as C - grasses and sedges; H - herbaceous; S - shrubs less than 2 m height; B - brush greater than 2 m height; and R - residual trees. The code is further elaborated upon with a rating of 1 to 5, 1 being less than 19% coverage and 5 greater than 81% coverage (Chaudry 1981).

With these procedures the individual species composing the non-crop vegetation are seldom listed even though it is now recognized that different species affect the crop tree in different ways and at different times during plantation development. Using the current provincial surveys, the competitive status of the plantation may be assessed during 'leaf off' when the presence and importance of lesser herbaceous and graminoid species can be severely under-estimated (Chaudry 1981).

New competition assessment procedures need to be:

- objective (not influenced by surveyor bias);
- capable of providing quantifiable measures of presence, frequency of occurrence, abundance and vigour of both non-crop and crop species;
- crop tree centered;
- capable of being applied in both the pre- / post- treatment condition;
- easily understood and applied;
- capable of being meshed with existing regeneration survey procedures such as stocking and Free-to-Grow surveys; and,
- capable of being incorporated into electronic data collection, analysis and report generation.

A NEW APPROACH - THE COMPETITION INDEX

Competition indices are a comprehensive method for combining descriptions of both crop and non-crop vegetation to produce a value which indicates the **relative** effect of non-crop vegetation on the crop species or the relative vigour of the crop. Buse and Towill (1991) provide a thorough review of this subject.

Field Data Collection

The northwestern Ontario competition index procedure is based upon data collected from a crop tree-centred plot of fixed radius (Figure 2). This permits the manager to undertake both pre- and post-assessments from known plots for purposes of evaluating treatment efficacy. The plot radius is fixed at 1.13 m corresponding to an area of 4 m^2 (i.e., the same as that used in stocking assessment surveys).

Variables measured on each plot include: crop tree total height and current height increment, total heights for each of the respective non-crop species (Figure 3; Table 1), and the percent vertical

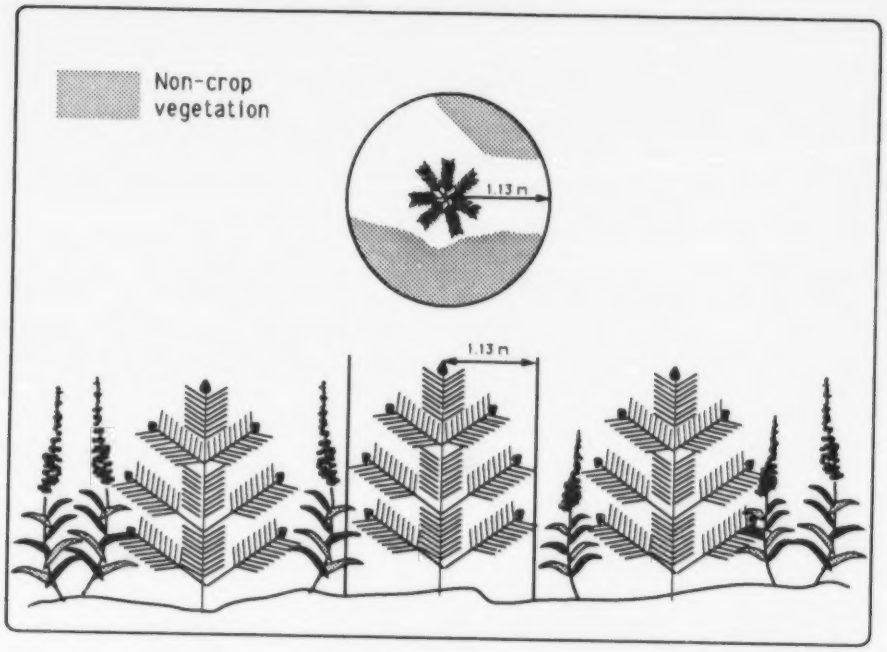

Figure 2. All competition index plots are crop tree centered with a radius of 1.13 m (4.0 m² area). A minimum of 40 randomly located plots per sampling strata are required. Competition index plots may also be incorporated into survival, stocking or Free-to-Grow survey designs.

coverage of the plot by each of the non-crop species (Figure 4; Table 1). Percent cover of ground herbaceous species is also recorded on each plot.

Percent cover is an easily estimated variable which is commonly used by ecologists to describe the abundance of a species. Cover for non-conifer species will vary depending upon micro-site, plot, age of the stand and the levels of inter-specific competition. The percent cover of major competitive species present on the plot should be recorded - not just the cover of the woody shrubs.

Percent cover estimations are recorded as an aerial or vertical projection view on the plot. Overlapping coverage from outside the plot is also taken into consideration; therefore, the total percentage ground cover per species on a plot may exceed 100 percent. This situation will also occur when more than one height class of an individual species is present on the plot (i.e. woody shrubs of indeterminate growth such as trembling aspen (*Populus tremuloides* Michx.). For example, you may have some 1.5 m high aspen stems covering 100 percent of the plot and several 3 m tall aspen stems with larger crowns also covering 100 percent of the plot area. Thus if tallied by height class, trembling aspen would be recorded as possessing 200 percent coverage of the plot. When this occurs each of the species-height strata combinations should be given unique names (e.g. Potr 3.0 , Potr 1.5) during the plot measurement.

To simplify assessments, the circular plot can be divided into equal quadrants and the percent cover of each species estimated by quadrant and then summed (Figure 4). This allows accurate estimation of the percent coverage of a species to the nearest 5 percent. When the competing species exists only as a singular stem, its cover should be entered as one percent.

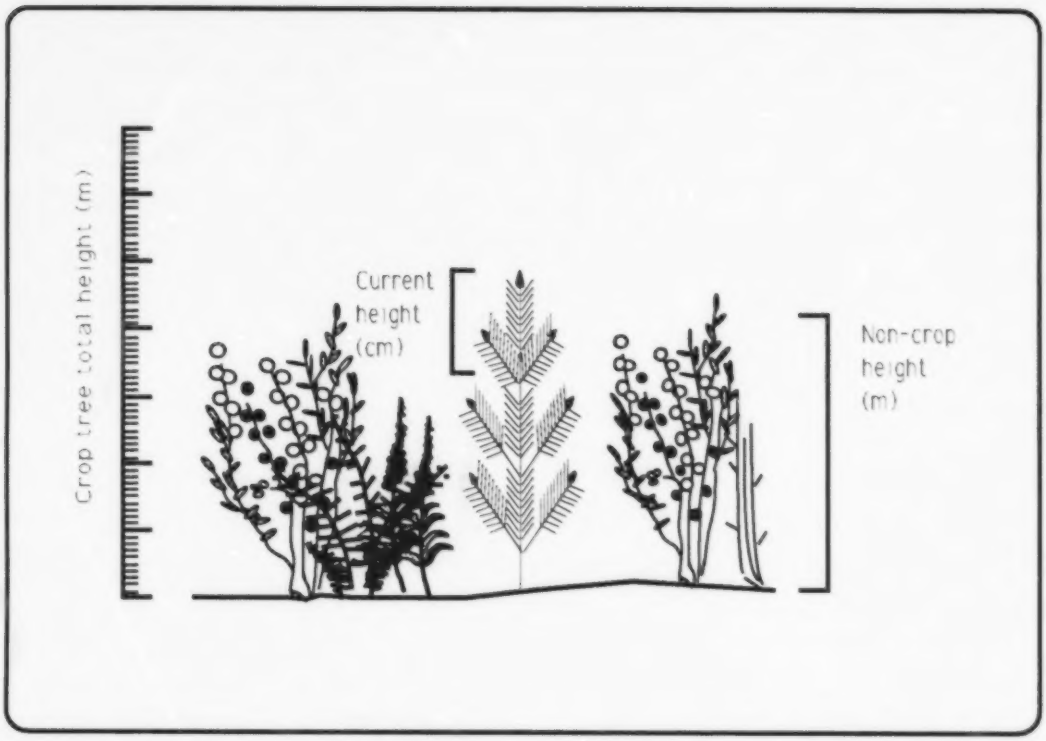

Figure 3. Crop tree measurements include total height (m) and the most recent complete current height increment (cm). Total height of the crop tree relative to that of the non-crop species (brush: crop tree height ratio) provides an indication of the relative performance of the crop species on the site. The average current height increment of the crop species can also indicate the relative vigour of the crop trees when compared to Free-to-Grow standards for the species.

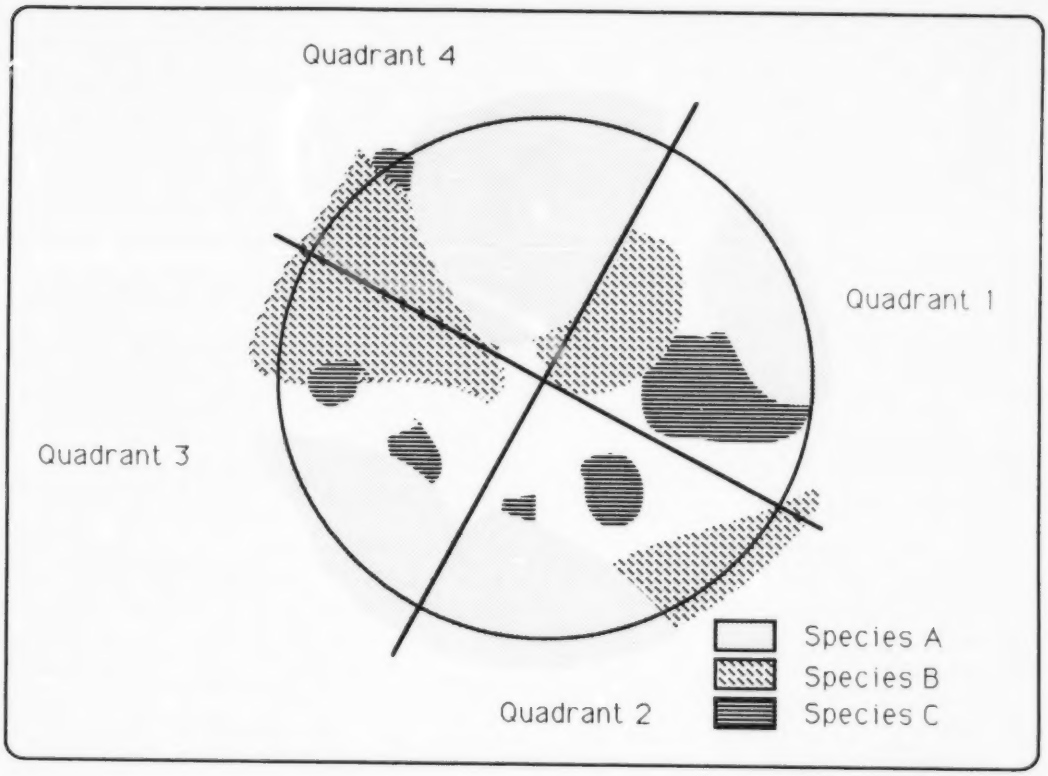

Figure 4. The abundance of each non-crop species surrounding the crop tree is evaluated by determining its percent coverage within the 1.13 m radius plot area. To accurately determine a species' percent coverage on the plot, calculate its coverage on each of the four quadrants and then sum.

Some woody species may occupy more than one district height class; separate percent cover estimates for each height class my be required. The percent cover of overlying but adjacent individuals is to be included for each species.

Species	Cover by Quadrant (%) 1	2	3	4	Plot Cover %
A	20	30	25	75	(20+30+25+75)/4 = 37.5
B	25	20	30	45	(25+20+30+45)/4 = 30.0
C	25	6	6	5	(25+ 6+ 6+ 5)/4 = 10.5

Table 1. Sample tally sheet for collecting competition index data.

PRE ☐ VEGETATION ASSESSMENT FORM
POST ☐ COMPETITION INDEXING

COMPLETED BY	PAGE	OF
ORGANIZATION		

DATE COMPLETED	

RECORD IDENTIFICATION

BASE MAP	M. UNIT	PROJECT NO.	AREA (ha)	YEAR PLANTED WK./MTH./YR.	SPECIES PLANTED	STOCK TYPE	SIP YR	SIP TYPE

SITE DESCRIPTION

FECV	FECS	SOIL TEXTURE	SOIL DRAINAGE/MOISTURE	CALCAREOUS	STONINESS	COMMENTS

FOR POST ASSESSMENT

AREA SPRAYED (ha)	CHEMICAL	APPLICATION TYPE	VOLUME (L/HA)	RATE (kg/ha)	COMMENTS

FIELD DATA

PLOT NO.	CROP SPEC.	HT (m)	COMP. SPEC.	AVG. HT. (m)	% G.C.	OVER HANG	HERB % G.C.	PLOT NO.	CROP SPEC.	HT (m)	COMP. SPEC.	AVG. HT. (m)	% G.C.	OVER HANG	HERB % G.C.

V.I. = MEAN COMP. HT. x MEAN % COVER
B / C ratio = MEAN COMP. HT. ÷ MEAN CROP HT.
C.I. = V.I. x B / C ratio

CODING OR COMMENTS

The competition index procedure also records the average height of each non-crop species on the plot. This is because differing height growth potentials among non-crop vegetation determines their ability to overtop a neighbouring conifer seedling. The average height is an approximation, derived from quickly measuring the varying heights of the individual stems within the plot border. The intent is to provide an indication of the non-crop species height.

Example:

The plot contains trembling aspen:

Ht. 1.5, 1.7, 1.9 m covering 35%
Ht. 1.0, 1.3, 0.7 m covering 10%
Ht. 0.3, 0.5, 0.4 m covering 3%

You may record as:

Comp. Spec.	Ht(m) Avg.	%G.C.
Potr	1.7	35
Potr	1.0	10
Potr	0.5	3

or average the height of the first two groups and adding their percentage coverage:

Potr	1.5	45
Potr	0.4	3

or average all heights and add percent coverage:

Potr	0.9	47

The level of detail included in the tally can be varied depending upon the objective of the survey.

Calculation of Vegetation Indexes (V.I.)

When the percent cover and average height of a non-crop species on an individual plot is multiplied together, the resultant value provides a relative indication of the amount of growing space volume surrounding the crop tree which is occupied by a non-crop species. This is referred to as the Vegetation Index (V.I.) (Figure 5) (Henderson 1986). At the stand level, the V.I. for each competing species would be calculated using the average total height and the average percent cover derived from the data collected on all of the plots in that stand.

Example:

Trembling aspen was found on 20 of 30 plots.

$$\text{Avg. height(m)} = \frac{(\text{ht.Potr-plot1}) + (\text{ht.P0tr-plot2}) + \ldots + (\text{ht.P0tr-plot20})}{\text{Number of stems}}$$

$$\text{Average percent cover(\%)} = \frac{(\%\text{cov Potr-plot 1}) + \ldots + (\%\text{cov Potr-plot2})}{\text{Total number of plots (30)}}$$

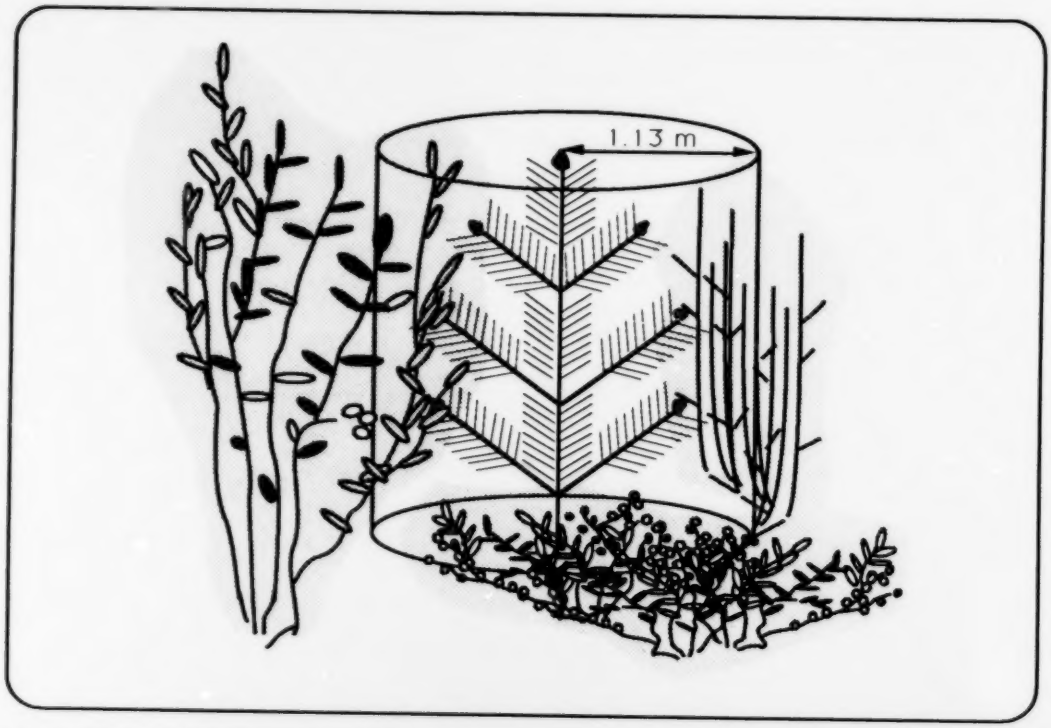

Figure 5.The Vegetation Index (V.I.) for a non-crop species is calculated by multiplying the percent cover for the species by its height (% cover X height). The V.I. provides a relative indication of the amount of the 'growing space volume' surrounding a crop tree being occupied by a non-crop species.

If the average height for trembling aspen was 0.9 m and if the average percent cover of aspen on all plots was 47 percent, then the Vegetation Index (Potr) would be calculated as follows:

V.I. (Potr) = 0.9 X 47 = 42.3

Individual Species Competition Indices (C.I.)

The relative impact of individual non-crop species on an individual conifer crop tree can be further expressed as a weighted average of the Vegetation Index (V.I.) multiplied by the ratio of the height of the non-crop (Brush) species to crop tree height (B:C ratio). Non-crop species whose average height is greater than that of the conifer crop tree are considered to exert more competitive pressure, especially for light (B:C ratio >1.00); those whose height is less than that of the crop tree exert less competitive influence (B:C < 1.00). The resultant product of this weighting process is defined as the Competition Index (C.I.) for the individual non-crop species.

Example:

Average height of Potr = 0.9 m

Average height of white spruce crop trees = 0.39 m

The B:C Ratio will be: 0.9 / 0.39 = 2.3

Continuing from previous example the Competition Index for trembling aspen on the site relative to the performance of the white spruce crop tree will be:

C.I. (Potr) = V.I. (Potr) X B:C ratio
= 42.3 X 2.3
= 97.3

Cumulative Competition Index

The Competition Indices for each competitive species on the plot are then summed to produce a Cumulative Competition Index value (C.C.I.) for the plot.

Where several plots of data exist, the Competition Index (C.I.) for the stand is calculated in the same manner as that described above. The exception is that average heights and percent cover for each of the non-crop species calculated using all the raw plot data is utilized in the calculations.

In all cases, it is assumed that the herbaceous species provide a uniform background level of competition. Therefore percent cover of herbaceous ground cover is recorded for information purposes only and is not used in the calculation of the Cumulative Competition Index (C.C.I.).

Example

Species	Freq. n = 20	Mean ht. (m)	Mean % Cov.	V.I.	B:C	C.I.	Diff.
Corycor	12	1.2	19.0	22.8	1.48	33.8	11.0
Rubus	18	0.6	28.9	17.3	0.74	12.8	-4.5
Potr	16	1.3	7.3	9.4	1.60	15.1	5.7
Acspic	2	0.7	1.3	0.9	0.86	0.8	-0.1
				50.4		62.5	

Mean crop tree height (Sw 2-2) = 0.81 m
Mean current annual height increment = 0.16 m

APPLICATIONS

Data collection and analysis may either be done manually using the forms shown in Table 1 or using an electronic data collection (EDC) terminal programmed with the necessary algorithms. An MS-DOS data capture, analysis and archival program capable of running on a DAP Industries - EDC terminal is available for this purpose which produces output similar to that displayed in Table 2 (Scott et al. 1991).

Since the non-crop vegetation reaches its maximum percent ground coverage once leaf development has been completed, field surveys to determine Competition Indices should be undertaken between July 8 and September 15 (prior to leaf fall and the first killing frost).

The Competition Index program may be used in assessing projects established through planting, seeding (broadcast or spot) or natural regeneration. In all instances the Competition Index is designed to evaluate the non-crop vegetation around **one specific crop species at a time** on the site. For example, a forest manager may have both black spruce and jack pine represented in the growing stock tally from an aerially seeded jack pine project. Both species are acceptable according to the silvicultural ground rules. However, since the forest manager's initial objective was to regenerate a jack pine stand, only jack pine should be selected to act as the crop tree plot centre. In

Table 2. Sample output-manual calculation of northwestern Ontario competition index value.

STOP #4: Adrian TWP. LOCATION: Stephens Lake
REF: TB-0240-52(87) AREA: 93 ha

HARVESTED: 1983 SITE PREPARATION: Mechanical 1984
METHOD: Cut and Skid TYPE: Barrels and Slash
TENDING: Chemical 1987
TYPE: Aerial Vision

REGENERATION: Planted 1985
STOCK: Sw 2-2, Sb 1 1/2 - 1 1/2
SPACING: 2.2 m x 2.2 m, Sb 2.2 m x 2.2 m

SOIL TYPE: Fine Sandy Soils

VEGETATION SUMMARY

SPECIES	FREQ. 28	X Ht	X % Cover	VI	B/C	COMP INDEX	DIFF
Rubus	22	0.5	17.1	8.56	0.62	5.38	-3.2
Potr	24	1.18	7.07	8.3	1.48	12.2	3.9
Corycor	12	0.90	7.5	6.0	1.0	6.0	0.0
Acspic	9	0.85	4.80	4.08	1.1	4.3	0.2
Alrug	3	1.7	0.96	1.6	2.1	3.4	1.8
				28.5		31.2	

Other species present with low comp. index values: Prunus, Betula, Salix
Crop Tree Species: Sw 2-2, Sb 1 1/2-1 1/2 X Ht = 0.80 m

this same example, it should be apparent to the user that the field crews will need instructions as to how to treat the black spruce when it occurs on a plot. Do they ignore it? Do they treat it as a 'competitive species'? This decision will be particularly important if the 'competition indexing' is being conducted in conjunction with another regeneration survey procedure such as 5th-year stocking or Free-to-Grow.

The resource manager must also decide which non-crop species are to be tallied during the assessments. A species list with alpha-coding should be provided to the field staff prior to initiating field work so that they can become expert at field recognition. The principle competing species will vary between units, districts and regions.

The sampling design for calculating the Competition Index for a project or strata is simple and closely resembles that used for stocking assessment surveys in Ontario (Chaudry 1981). The first task is to evaluate the uniformity of condition within the block prior to initiating the survey. This is commonly done in the office using Supplementary Aerial Photography (SAP) or in the field by walking the block prior to the survey. The regeneration project may be stratified according to where the different species or stock types have been planted, by age of the regeneration treatments within a block, by former stand conditions (e.g. mixedwood versus conifer) or by some soil/site attribute etc. **Sampling should only occur within a well-defined strata.**

On the ground, systematically located plots (1.13 m radius) are established at known variable intervals along randomly-located sample lines. If the site has been mechanically site-prepared using a continuous furrow implement, the cruise lines should be located perpendicular to the direction of travel of this equipment. Distance between the lines will depend upon the size and shape of the stratified block and the homogeneity of the non-crop vegetation.

Although the distance along the cruise line has been pre-determined and located on Supplementary Aerial Photography, the assessor may not find a crop tree for plot centre at their feet. The prescribed method for locating a crop tree centre is as follows: after coming to a halt, look for a crop tree directly in front or within 1.13 m on either side of the cruise line. If no crop tree is found continue along the swath on either side of the cruise line until a crop tree is encountered. Where two or more trees qualify, choose the tree closest to the cruise line, but never go back to locate a tree.

In many situations it is desirable and possible to include Competition Index data collection during stocking assessments. A Competition Index plot should be established around the nearest crop tree located outside of the third quadrat of each cluster. It doesn't matter which side of the cruise line you choose but be consistent to avoid subjectively selecting bigger crop trees. By collecting data on a separate plot outside the usual four clusters, the field assessors will not have to worry about assessing percent cover based upon partially trampled vegetation.

A minimum of 40 plots per stra^a should be measured regardless of the size of the area due to the extremely high variability in species composition and growth potential during early successional stages.

Plot boundaries do not have to be permanently marked for purposes of the assessment. The assessors should carry with them a pole or rod with 1.13 m clearly marked on it so that a visual plot boundary may be established. This works best if the assessor locates himself beside the crop tree centre.

If the purpose of establishing the plots is to evaluate the effectiveness of a certain tending, release or vegetation management treatment, then the plot centre may be staked and labelled to facilitate post-treatment analysis. This will facilitate linking crop tree growth (post-treatment) to a specific vegetation condition.

OTHER CONSIDERATIONS

Caution should be used in interpreting Competition Index values. It is important that individual species, heights, percent cover, C.I.'s as well as the C.C.I. be compared. It is recognized that individual competing species should receive further weighting to reflect differences in their competitive mechanisms and potential to affect our major conifer species. The autecology and synecology of many of our principle non-crop species are now being studied and will provide a basis for future refinements to the Competition Index.

Additionally, it must be noted that studies quantifying the relationship between the index and crop tree growth and survival or browse availability are not widespread - therefore the C.C.I. values must be viewed in the most general of ways, that of relative abundance and presence of non-crop vegetation as related to crop species size. Values will commonly range from 0 to 1200 with even larger values possible. These C.C.I. values can be used to rank stands for tending with areas having large C.C.I.'s receiving priority.

Future improvements to the Competition Index model must include site-specific information which will project the development of inter-specific competition in plantations from both a crop and competitor perspective. The utility of applying the Competition Index in stands which have achieved the Free-to-Grow status or beyond also needs investigation.

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